who served as astronomer; Dr. H. Alme, of the Meteorological Office at Stockholm, who joined the expedition at Tromsoe and served as meteorologist. The general spirit of the expedition was not that of scientific exploration, but the two gentlemen here referred to accomplished all that was possible under the circumstances In 1895 the Chief of the Weather Bureau received from Dr. Alme his report communicating the meteorological results, and on consultation with Mr. Wellmann was assured that there was no objection to the publication of this report, but that he considered Mr. French as responsible for all the work. Accordingly correspondence was opened with Mr. French, who, after unforeseen delays, owing to his absence in the field work of the Coast and Geodetic Survey, has only lately been able to complete the reduction of his astronomical observations and give the proper locations and charts showing the points at which the meteorological work was done. The Editor takes pleasure in being able now to announce that the combined reports of Messrs. French and Alme will be printed as a bulletin of the Weather Bureau. It is always proper and important to publish, in all possible detail, any observations made at an isolated point so far removed from ordinary meteorological stations, and so essential in filling up the daily map for tracing storms and weather over the North Atlantic Ocean.

RAINFALL MEASUREMENTS ON SHIPS.

It has been customary for navigators, in keeping a meteorological record, to express the rainfall only in the most general terms; but, inasmuch as a complete study of the meteorology of the globe requires a positive knowledge of the amount of rainfall, it behooves us to make every possible effort to remedy this great deficiency in our knowledge. In former days it was assumed that the rain gauge must be a fixture with its mouth perfectly horizontal at an elevation of not more than 1 foot above the earth's surface, while a gauge set in a shallow pit so that its mouth is on a level with the surrounding soil was widely adopted as the standard. The invention of shielded gauges by Prof. Joseph Henry, in 1858, and Professor Nipher, in 1878, and of the protected gauge of Bœrnstein, in 1884, together with a better appreciation of the action of the wind upon the gauge, as affecting its catch, have effected a radical change in our views. The height of the gauge above the ground does not materially affect the catch or the apparent rainfall, provided that we adopt some method of annulling the influence of the wind. Shielded or protected gauges give the same rainfall in all open localities, and it seems to be high time that they should be established and used at sea. The errors to which such gauges will then be subject will arise principally from the fact that they are liable to be in the shelter of a sail or bulwark, of a deck house or a smokestack. If established on a steamer near each end of the bridge occupied by the pilot or navigating officer, the average of the two gauges can apparently only be affected by the influence of the rolling of the vessel, and if mounted on gimbals, this latter is reduced to a minimum. If established on a steamship or sailing vessel, the gauge that is to windward of the sail should be employed; but the gauge that is to leeward should be read and recorded, in order to appreciate the amount that it has lost by its sheltered position.

The latest effort in this line of work is that of Dr. W. G. Black, whose paper on this subject, read before the Manchester Geographical Society in October, 1897, is summarized on page 206 of its Journal, Vol. XIII. The complete paper is published, with a chart of ocean rainfall, in the same Journal, Vol. XIV, pp. 36–56. Rainfall tables are given for each ocean, based on observations made with marine rain gauges (generally Dr. Black's pattern of 1870–72), during many voyages between 1864 and 1880, by about twelve steamships or steamers. Dr. Black illustrated his address and explained the use of the large box and small leather rain gauges; the gimbal stand for the rain gauge, with its ring and dish and louvre protection, and, finally, the wind gauge. The following are the conclusions to which Dr. Black has come on the question of oceanic rainfall:

1. More rain falls at sea in the Northern Hemisphere (Atlantic, Indian, and China seas) than in the Southern Hemisphere, by 91.15 inches to 66.33 inches; but there are fewer rainy days, by 162 to 182.
2. The rate of rainfall is heavier in the Northern Hemisphere than in the Southern Hemisphere by 0.562 inches to 0.364 inches per diem of wet days.
3. The percentage of wet days to total days in the Northern Hemisphere is about 24, and in the Southern Hemisphere is 23.
4. Most rain was collected in the month of September in the Northern Hemisphere, and in April in the Southern Hemisphere, both being autumn months.
5. The rate of rainfall per annum in the Northern Hemisphere was 50.56 inches and in the Southern Hemisphere 30.76 inches, or two-fifths less.
6. Least rain was collected in March in the Northern Hemisphere and in October in the Southern Hemisphere, both being spring months.
7. The greatest number of rainy days in the Northern Hemisphere was in September, 33, and in the Southern Hemisphere in April, 25; autumnal months.
8. The least wet days in the Northern Hemisphere were in March, 5; in the Southern Hemisphere, 1, in October; spring months.

We have, unfortunately, no further details of Dr. Black's apparatus, but we have no hesitation in recommending shielded or protected gauges, whether on gimbal stands or not, for general use at sea, as being a great advance over our present absence of rainfall measurements.

CLIMATES OF GEOLOGICAL AGES.

An article by Prof. T. C. Chamberlin in the Journal of Geology for November, 1897, vol. V., p. 653, contains a review of a number of hypotheses bearing on climatic changes during geological ages. In common with all modern geologists, Professor Chamberlin recognizes that the atmosphere is the most active of all geological agencies.

Its very activity destroys its relics almost as soon as formed and gives them peculiar evanescence. This has invited the neglect of geologists laudably prone to concentrate their attention upon agencies which have left enduring and unequivocal records. * * * All our attempts at the solution of climatic problems proceed on some conscious or unconscious assumption concerning the extent and nature of the atmosphere at the stage involved.

After showing that the carbon dioxide now in the atmosphere would not last ten thousand years at the present rate of consumption, and that we are confronted by the necessity of finding some compensating source of supply, he appeals to the ocean as being an atmosphere in storage, holding in solution about eighteen times as much carbon dioxide as does the atmosphere itself. He finds that the flora and fauna of Paleozoic and Cenozoic times do not imply any great difference between the earlier and the present atmosphere, but that during the Carboniferous period there may have been many thousand times as much carbon dioxide as now. One might assume that our atmosphere has been successively fed and robbed of this gas. After computing from the best data available the power of a hot atmosphere and molten earth to retain the various gases whence it follows that hydrogen, at least, would escape into space away from the earth's attraction quite rapidly, and after accepting the probability that in some way or other the earth and atmosphere have received compensating accretions slowly by the fall of meteorites without an appreciable increase of temperature, he proceeds to work out this idea more in detail, finding many analogies in the present condition of the moon. In general, our atmosphere was derived from the interior of the earth, but after the earth had reached the requisite size, it would be supplemented by the collection of wandering gases. All this, of course, took place while the temperature of the surface was above that of boiling water and before the ocean, as such, could exist. The combined mass of the atmosphere and the ocean are little more than $\frac{1}{5000}$ of the mass of the earth. At that time the matter that now constitutes an earth of average specific gravity 5.6 was so swollen by heat as to have an average of 3.5. If we consider this mass as simply contracting to its present dimensions, the corresponding fall of each particle toward the earth's center would, by the conversion of gravity into heat, be capable of raising the whole mass to a temperature of 6,560° C., or far above the average melting point of rocks on the surface. Whether or not the earth and atmosphere ever went through this particular stage in progressive self-condensation, it is at least probable that something like that must have gone on in connection with the formation of the ocean depressions and continental elevations and the subsequent great crumplings and crushings of Archæan ages.

The mountainous wrinkling of the crust in Post-Cambrian times is now going on in this epoch in gentle earthquakes. * * * There does not, therefore, seem to me any firm ground, even on current theories of the earth's origin, for insisting on the acceptance of the doctrine of a vast primitive atmosphere, as the great reservoir from which subsequent abstractions have been chiefly taken. I think we are free, therefore, to assume just such a Paleozoic atmosphere as the life and deposits of that time seem to imply, interpreted by the phenomena of to-day. Such an interpretation seems to me to indicate conditions not radically dissimilar to those of the recent geological ages; warm climates in high latitudes at times, colder climates in lower latitudes at times, moisture at times, aridity at times, and like oscillations. This view carries with it the necessary corollary that the atmosphere has been suppliedby accessions in some new proportion to its losses.

The author then gives some plausible reasons for the fluctuation in supply and exhaustion of the atmosphere; among these it is noticed that when a general uplift of the crust occurs the area of the ocean is diminished and the area of high land increased with an increase of the atmospheric exhaustion or impoverishment, so that, in general, atmospheric poverty lags some distance behind the stages of general elevation and *vice versa*. The author also assumes that atmospheric poverty, especially in the critical item of carbon dioxide is correlated with low temperatures. Tyndall suggested that carbon dioxide had a peculiarly powerful influence in absorbing solar radiation, and Arrhenius has lately computed what degree of depletion of the carbon dioxide at present in the atmosphere would bring about the glaciation known to have prevailed in Pleistocene times. He finds that the removal of 38 to 45 per cent will do this and that, on the other hand, an increase of two or three times its present value would produce the mild temperatures of the Tertiary times. But the elevation of a continent, the resulting glaciation and diminution of forests, or other plant life, eventually checks the absorption of carbonic acid gas, and by leaving more of it in the air, contributes to warm the atmosphere and check the glaciation. We have, therefore, an alternation of cold and warm periods due to the interaction of elevation and carbon dioxide.

Meteorologists and climatologists will certainly be pleased to find geologists agreeing that the climatic peculiarities of Pleistocene and subsequent ages were due to an atmosphere similar to that which now envelopes the earth; that oceans and continents in those days were not so greatly different from the present day, and that the great climatic changes required to cover the interior of the United States and Canada with a vast glacier similar to that which now covers Greenland, may have been brought about by a redistribution of highlands and lowlands. The problems of geological climatology are thus brought within the realm of the modern climatologist. The arguments that apply to existing climates will also apply to those of earlier eras. When we can explain why it is that glaciers are now formed in Greenland but not in our Lake region then we shall be able to state the conditions under which formerly glaciers were formed in the Lake region but not in Greenland. To the Editor these seem to be merely questions of aerodynamics.

Given a certain distribution of highland, lowland, and ocean over the whole earth's surface, we hope eventually to be able to deduce the resulting climatic peculiarities, and to show that very slight changes in oceans and continents have produced all the variations of geological climates, and that little or nothing need be hypothecated as to the variations of solar heat, of atmospheric gases, of terrestrial latitudes, or the many other climatological elements.

BAROMETRIC READINGS CONVERTED INTO STANDARD PRESSURES.

In the Annual Report of the Chief Signal Officer for 1881, pages 1126–1137, will be found a study of the corrections to the standard mercurial barometer of the Signal Service, in which instrument English scales and Fahrenheit thermometers are used. In this work it was proper to assume that the temperature of the brass scale and that of the mercury inside of the glass tube might differ appreciably, possibly by several degrees. Therefore thermometers were so placed as to give each of these temperatures separately. Two tables were computed, which were published at the close of the article referred to, by means of which the correction for temperature of the scale might be obtained and applied independently of the correction for the temperature of the mercury.

In using these and similar tables of corrections, it is assumed that the zero of the scale is precisely at the end of the ivory point to which the mercury is adjusted in the cistern of the barometer, so that, for instance, 30.500 on the brass scale really means that exact number of apparent inches on a brass scale whose coefficient of expansion for 1° F. is 0.0001043 of the observed length. It is also assumed that the average temperature of the scale is exactly known by means of several thermometers, if need be, whose individual errors have been allowed for. It is furthermore assumed that the brass scale is of correct standard length only when its temperature is 62° F. If b'' is the observed scale reading or "apparent length," and t'' is the observed temperature of the scale, then the correction for the reduction of the scale to standard length is computed by the formula:

$$\text{Correction} = b''\,(t'' - 62^\circ)\,0.0001043.$$

This formula is represented by the following abstract of Table I:

TABLE I.

t''.	b''=29.5.	b''=30.5.
°*F.*	*Inch.*	*Inch.*
30.....	−0.0098	−0.0102
40.....	0.0068	0.0070
50.....	0.0037	0.0038
60.....	−0.0006	−0.0006
70.....	+0.0025	+0.0025
80.....	0.0055	0.0057
90.....	0.0086	0.0089
100.....	+0.0117	+0.0121

Having corrected the brass scale reading so as to get the height of the mercurial column in standard inches, we must